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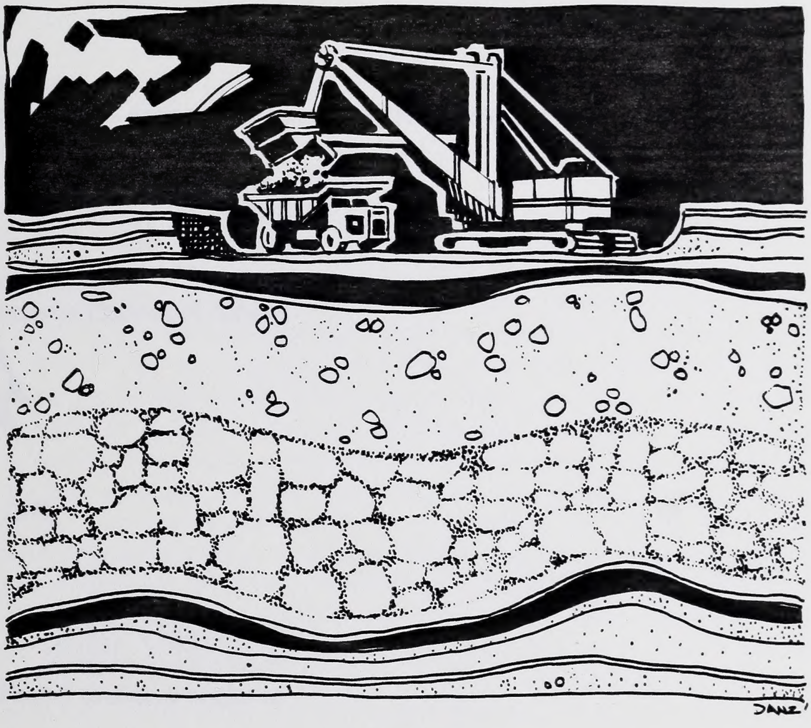
Foundations for the Future

Alberta's Mineral Resources



A discussion paper prepared for the Alberta Conservation Strategy Project

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Foundations for the Future

Alberta's Mineral Resources

Prepared by
Energy and Non-Renewable Resources Sub-Committee
Public Advisory Committees
to the Environment Council of Alberta

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FOREWORD

In late 1985, the Public Advisory Committees to the Environment Council of Alberta began working toward a draft conservation strategy for Alberta. The Public Advisory Committees (PACs), comprising representatives of some 120 non-government organizations, are in many ways an ideal organization for developing a strategy that should touch the lives of all Albertans. The PACs bring together many diverse viewpoints, we are non-partisan, and we have members from across the province. Since the early days of the project, we have welcomed non-PAC participants, and have been delighted to receive the contributions of civil servants, industry spokespeople, academics, and the general public.

We have made progress since 1985: the *Prospectus for an Alberta Conservation Strategy* has been published and many meetings and workshops have been held. The principle of a conservation strategy increasingly has been endorsed by Albertans, and Alberta has been recognized across Canada as a leader in conservation strategy development. There have been important related events. For example, in September of 1987, every environment minister in Canada endorsed the final report of the National Task Force on Environment and Economy, which recommended that conservation strategies be in place in every province and territory by 1992. This same report was endorsed by the First Ministers at their November, 1987 meeting.

We will have a conservation strategy for Alberta, we hope by 1990, the Canadian Year of the Environment. Our work continues in the expectation that all those who are interested will have a chance to contribute to the project, through public hearings or some other public participation process.

Since the publication of the *Prospectus*, the PACs have concentrated on preparing sectoral discussion papers. The Conservation Strategy Steering Committee determined early on to produce background papers on relevant sectors, such as agriculture, fish and wildlife, tourism, oil and gas, and others. These discussion papers look at the issues within each sector, but, more importantly, they investigate the interaction of each sector with the others. Their preparation has involved consulting with a wide range of interest groups — a conservation strategy principle in action — which has proven fruitful in developing ideas about the ultimate conservation strategy. These discussion papers will be used as background information for drafting a conservation strategy document and, perhaps, in the future, in public hearings on the draft conservation strategy. This report is one in the series of discussion papers.

Because there are as many opinions on our best future direction as there are Albertans, we welcome comments. The conservation strategy will be only as good as the work that goes into preparing it. Please address any comments on this discussion paper or others in the series to the Environment Council of Alberta at the address given on the page opposite. I would also encourage you to make your opinions known at public hearings or other events as they are held. Let's treat Alberta as if we plan to stay!

Joan Snyder

Joan Snyder
Chairperson
Conservation Strategy Steering Committee
Public Advisory Committees to the Environment Council of Alberta

ABOUT THIS DISCUSSION PAPER

Extraction of our mineral resources not only contributes to Alberta's economy, but also produces materials — especially structural minerals such as sand and gravel — that are crucial to the engineered works of Alberta's cities, transportation systems, and industrial facilities. The availability, quality, and quantity of these minerals can affect growth in other sectors of the economy. Other development activities, however, can limit our options for wise use of Alberta's mineral resources.

This paper discusses the contribution of our non-energy mineral resources to Alberta's economy. It also looks at factors to consider in developing mineral management strategies that will support long-term economic development. As a discussion paper prepared for the Alberta Conservation Strategy, the minerals sector paper is intended to stimulate thought and discussion about how these non-renewable resources can best be managed to assist Alberta in developing a sustainable economy.

ACKNOWLEDGEMENTS

The Energy and Non-Renewable Resources Sub-Committee of the Public Advisory Committees to the Environment Council of Alberta is pleased to provide this discussion paper to the public of Alberta. The Sub-Committee owes a special thanks to Helen Heacock, who represents the Local Council of Women (Calgary) on the Sub-Committee. Helen has represented the minerals sector on the Alberta Conservation Strategy Steering Committee. The Sub-Committee also acknowledges the Sub-Committee members who took interest in this paper and devoted their time to discussing the content and reviewing earlier drafts. John Lilley of the Environment Council staff provided very able assistance with research, compilation of information, and writing, and other ECA staff assisted with typing, editing, and production.

The Sub-Committee owes a special thanks to several other people who volunteered to review this paper. Per Andersen, Alberta Forestry, Lands and Wildlife; Dixon Edwards, Alberta Research Council; Brian Hudson, Alberta Energy; Don Currie, Alberta Chamber of Resources; John King, Alberta Environment; and Dr. John Godfrey provided useful comments, suggestions, and additional material. We are grateful to these people; nevertheless, the contents of this paper are the responsibility of the Sub-Committee and do not necessarily reflect the views of those people whom we gratefully acknowledge.

March 1989

Contents

1. Introduction **1**

Metallic Minerals 1

Non-metallic Minerals 1

Structural Materials 1

2. Economic and Social Significance **2**

Metallic Minerals 3

Non-metallic Minerals 6

Structural Materials 8

3. Demand Projections **10**

Metallic and Non-metallic Minerals 10

Structural Materials 10

4. Managing Resources For The Future **12**

5. Interactions With Competing Uses **15**

Restrictions on Land Use 17

Operational Impacts 18

Reclamation Opportunities 18

Resource Sterilization 19

6. Legislative and Regulatory Regime **20**

7. Conclusion **22**

References **24**

Part One

Introduction

Minerals are naturally occurring substances with a characteristic composition expressed by a chemical formula. They may occur as pure crystal deposits or may be disseminated in some other mineral or rock.

Some mineralogists require an inorganic origin in their definition of minerals. This "inorganic origin" restriction excludes coal, oil, and gas. For our purposes, this is a convenient distinction, because coal, oil, and gas are the subjects of other discussion papers in the conservation strategy series.

Minerals, at least those of inorganic origin, typically are obtained by mining, although there are exceptions, such as the recovery of sulphur from sour gas and the production of salt from brine wells. Minerals are commonly divided into three categories: metallic minerals, non-metallic minerals, and structural materials.

Metallic Minerals

Metallic minerals are substances that are crystalline when solid. Many are opaque, ductile, malleable, of high specific gravity, and good conductors of heat and electricity. The only metallic mineral currently produced in Alberta in any substantial amount is gold. Minor amounts of platinum and calcium chloride also are produced.

Non-metallic Minerals

Minerals that do not have the characteristics of ductility, malleability, and conductivity are classed as non-metallic minerals. Those produced in Alberta include salt, silica, and sulphur, and lesser amounts of sodium sulphate, gemstones, peat, and bentonite (Hamilton and Hora 1987).

Structural Materials

The third category of minerals, structural materials, is a grouping of convenience and function. Included are minerals that often consist of several substances in combination. These minerals are used primarily in the construction industry and include sand and gravel, decorative and building stone, cement, clay, and limestone. Limestone is also used in non-structural applications, including the production of lime.

Because of the distinctive differences among the metallic minerals, non-metallic minerals, and structural materials, these resources are discussed separately in the next two sections on economic and social significance and demand projections.

Following these sections, minerals in the all-inclusive sense are discussed in the sections on managing resources for the future, and interactions with competing uses. These latter aspects of mineral development are quite similar for all three categories, because all three are non-renewable, and interactions caused by mining all types of underground resources are similar.

Minerals are naturally occurring substances with a characteristic composition expressed by a chemical formula.

Part Two

Economic and Social Significance

In 1987, the production of inorganic minerals in Alberta was valued at $948,715,000, divided as follows:

Metallic minerals	$658,000
Non-metallic minerals	$641,696,000
Structural materials	$306,361,000

Table 1 clearly indicates the important economic contribution of sulphur (a non-metallic mineral) and structural materials to the primary minerals industry in Alberta.

In 1987, elemental sulphur accounted for almost 65 percent of the value of Alberta's mineral production (excluding fuels). Sulphur is extracted

Table 1. Value of Mineral Production in Alberta, 1987 *

	Dollars	Amount
Metals		
Gold	329,000	17,000 grams
Other metals	329,000	—
Subtotal	**658,000**	
Non-metals		
Sulphur	604,805,000	6,583,000 tonnes
Peat	14,395,000	74,000 tonnes
Quartz	4,300,000	—
Salt	15,380,000	1,470,000 tonnes
Sodium sulphate	2,816,000	—
Subtotal	**641,696,000**	
Structural Materials		
Cement	132,060,000	1,075,000 tonnes
Sand and gravel	141,025,000	44,350,000 tonnes
Clay products	14,063,000	—
Lime	17,738,000	260,000 tonnes
Stone	1,475,000	260,000 tonnes
Subtotal	**306,361,000**	
Total	**948,715,000**	

Source: Energy Mines and Resources Canada. 1988. *Canada's Mineral Production — Preliminary Estimate.* Catalogue No. 26-202.

* Does not include fuels.

from sour gas or recovered during the production of synthetic crude oil from Alberta's oil sand deposits. Because sulphur production is an integral part of oil and gas development, the environmental implications and future development potential are discussed in more detail in the oil and gas sector discussion paper.

Structural materials make up almost one third of the value of Alberta's mineral production (excluding fuels). Based on value, Alberta accounts for about 41 percent of the structural materials produced in Western Canada and is the second largest provincial producer of sand and gravel, exceeded only by Ontario (EMR 1987).

The potential of the minerals sector in Alberta has not been fully established nor have known deposits been fully exploited. Expanded mineral development could be profoundly important to Alberta in terms of economic diversification, employment, geological and mining technology, and human resource development.

Already, the mining, processing, production, and shipment of industrial minerals are a large and important part of Alberta's economy. In addition to this primary industry, plants that use industrial minerals as raw materials account for 5.8 percent of total manufacturing employment. Industries producing products such as cement, ready-mix concrete, clay products, salt (chlor-alkali), and lime have key roles to play in Alberta's growth (Currie, pers. comm., July 1988)

Metallic Minerals

Several metallic minerals are found in Alberta and other deposits are known to occur in adjoining states and provinces (Figure 1). Potential for major metallic minerals production exists mainly in the Precambrian Shield in northeastern Alberta, and in the iron ore deposits of the Clear Hills area in northwestern Alberta.

In the late 1800s and early 1900s, a few small copper or copper-silver mines operated in the Rocky Mountains in the southwestern part of the province, but Alberta does not currently have any operating metal mines. Nevertheless, gold production contributed 50 percent of the total value of metallic minerals produced in Alberta in 1987 (Table 1). This gold is largely extracted by the washing operations of large gravel producers. A minor amount is produced by placer operations, most of them quite small, in the foothills and eastward, including several in the North Saskatchewan River near Edmonton. Steady gold prices have sustained interest in placer mineral rights. Four placer mineral leases were issued and four leases renewed in the fiscal year ending March 31, 1987 to extract "flour" gold from sand and gravel deposits (Alberta Energy 1988). As well, 129 placer mining permits were issued to "hobby" prospectors, bringing to 839 the number of placer mining permittees in Alberta.

The Alberta government is promoting exploration for metallic minerals (Alberta Chamber of Resources et al. 1987). Exploration is warranted because Alberta's geology is varied and favors mineral deposits. There are several known metallic mineral occurrences, a large geological and geophysical data base, and a favorable regulatory and taxation regime. The Government of Canada also is trying to increase exploration and development of mineral resources. To make mineral development more attractive to foreign capital, the earlier practice of seeking 50 to 60 percent Canadian equity in new non-fuel mineral resource projects has been set aside (EMR 1987).

The potential of the minerals sector in Alberta has not been fully established nor have known deposits been fully exploited.

These efforts are bearing fruit. As of March 31, 1987, there were 18 active metallic minerals exploration agreements and seven development agreements in Alberta (Alberta Energy 1988). These agreements covered 75,000 hectares. Extensive drilling has been conducted on a number of permits and leases. Although no major discovery of mineralization has been announced, $1.04 million in security deposits, held against minimum assessment work expenditure requirements, has been refunded, a clear indication of the significant increase in metallic mineral exploration in the province (Alberta Energy 1988). Whether these efforts result in the development

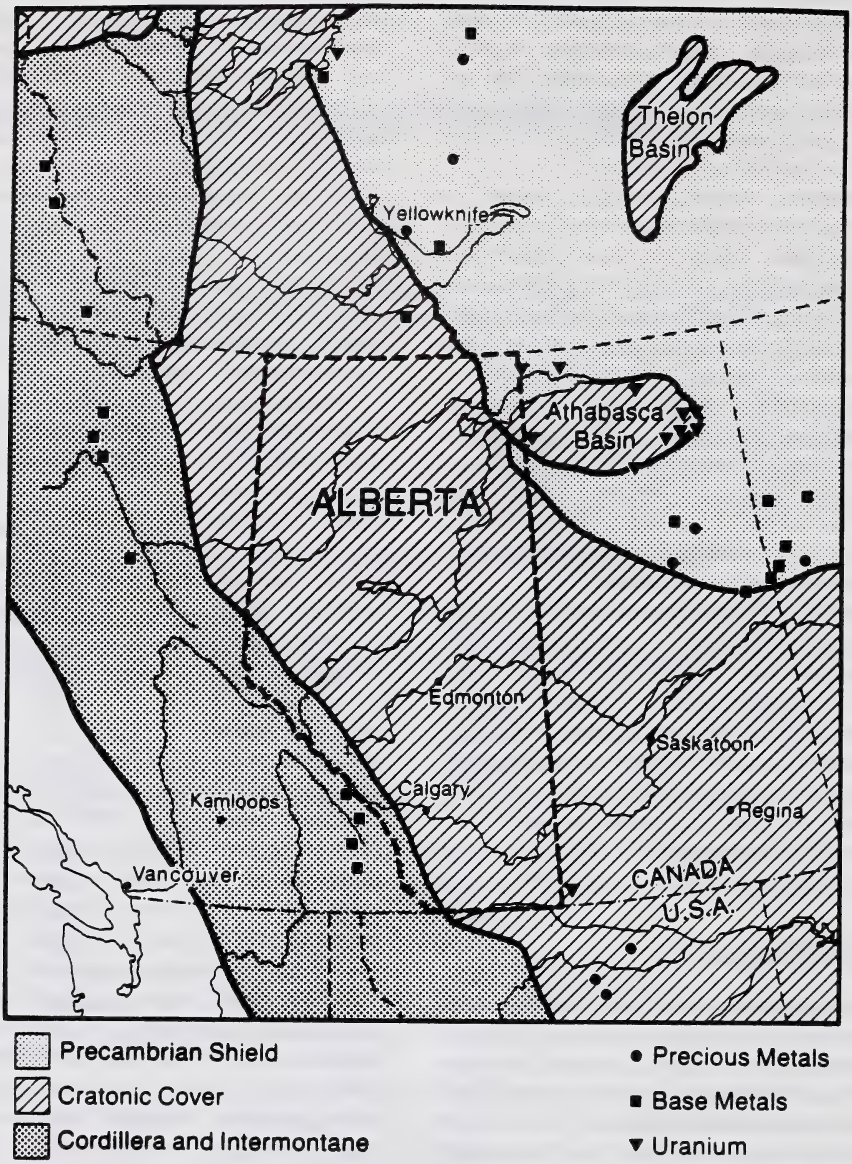

Figure 1. Known Mineral Deposits in the Vicinity of Alberta

Source: Alberta Chamber of Resources, Alberta Energy, and Alberta Geological Survey. 1987. *Alberta: Opportunities for Metallic Minerals.*

of mineral resources remains to be seen, but according to Edwards (1988), the lack of large-scale metallic mineral production may indicate an undeveloped opportunity rather than a lack of geologic potential. This view is shared by the Alberta Chamber of Resources:

> *Alberta is bounded by significant mineral deposits. Only the lack of exploratory effort is to blame for no discovery.* (Currie, pers. comm., July 1988).

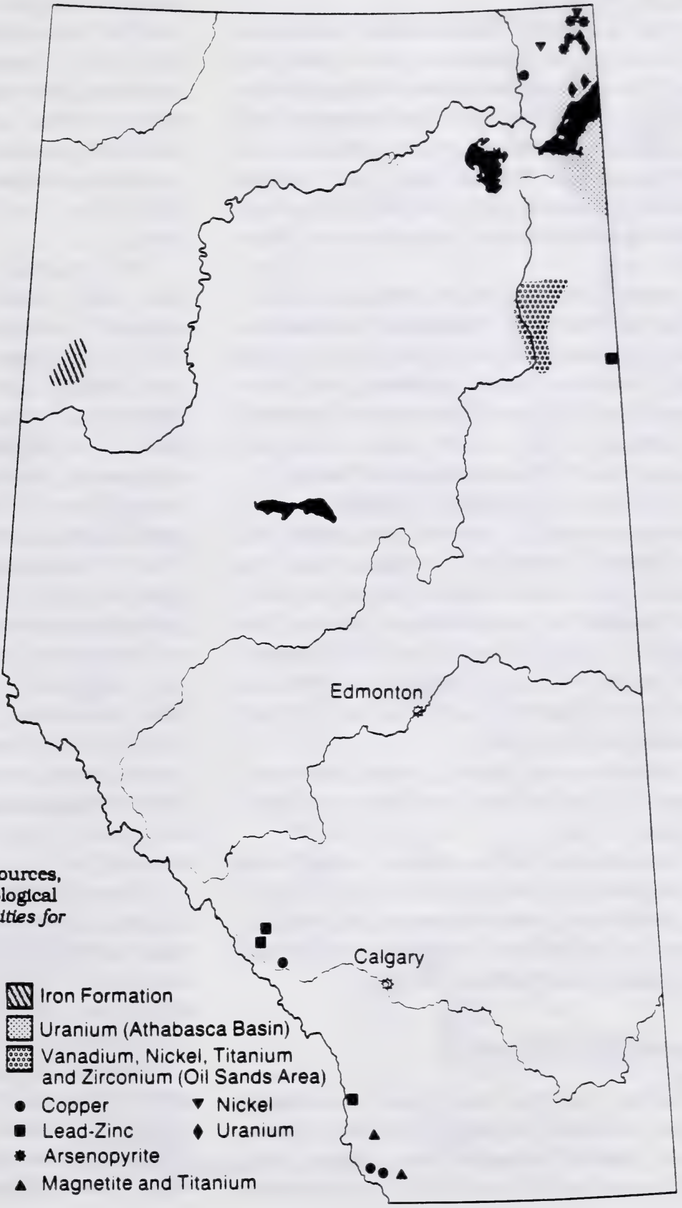

Figure 2. Metallic Mineral Occurrences in Alberta

Source: Alberta Chamber of Resources, Alberta Energy, and Alberta Geological Survey. 1987. *Alberta: Opportunities for Metallic Minerals.*

The Precambrian Shield of northeastern Alberta has potential for gold, silver, copper, nickel, lead-zinc, platinum elements, and possibly rare earth minerals (Edwards 1988). Northeastern Alberta is also an area of active exploration for uranium. Other areas of the province have formations that favor these minerals, as well as magnetite (see Figure 2).

Alberta's largest known metallic mineral occurrence is an iron deposit near Peace River. This deposit has 200 million tonnes of strippable ore, averaging 35 percent iron. Development is still awaiting an economically viable upgrading and smelting process. The low grade and complex metallurgy of the ore have prevented development to date (Alberta Economic Development and Trade 1987).

Heavy minerals, including titanium and zirconium, occur in trace amounts in the Athabasca oil sands. These minerals are concentrated in the tailings during oil sands processing and constitute 20 to 25 percent of the mineral solids in the tailings, which is 100 times more concentrated than in the unprocessed oil sands.

At these concentrations, the tailings are a potential commercial source of these metals and their oxides. Significant volumes could be produced from the enormous tonnages of oil sands handled in the extraction process. The tailings from the Syncrude plant, for example, could provide 114,000 tonnes of titanium minerals and 22,000 tonnes of zircon per year (Hamilton and Hora 1987).

Vanadium and nickel, other trace constituents of the bitumen, also have economic potential.

In other areas of the province, waters from specific geological formations have been studied and identified as potential sources of calcium, lithium, and magnesium. A magnesium plant has been proposed for southern Alberta.

Non-metallic Minerals

Non-metallic minerals contribute considerably more to the value of mineral production in Alberta than do metallic minerals, even excluding sulphur production. The total value of non-metallic mineral production (excluding sulphur) was almost $37 million in 1987. The products were primarily salt and peat moss, with lesser values of quartz and sodium sulphate. Silica, bentonite, and gemstones are also produced.

As with the metallic minerals, opportunities exist to increase extraction of non-metallic minerals (see Figure 3). Hamilton and Hora (1987) identified opportunities for new production or expansion of present production of diamond, iodide and bromide from brines found in geological formations, glauconite, graphite, gypsum, leonardite, limestone and dolomite, niobium and tantalum minerals, phosphate, and silica.

Heavy minerals, including titanium and zirconium, occur in trace amounts in the Athabasca oil sands.

For example, the only silica produced in Alberta currently comes from relatively low-grade sand dune deposits near Edmonton. This type of deposit is extensive in Alberta, but is of marginal grade, ranging from 90 to 95 percent silica dioxide. Consumption of silica sand in Alberta is about 100,000 tonnes annually for making glass and glass fiber and another 100,000 tonnes per year for hydraulic fracturing, sand blasting, foundries, and other uses (Alberta Economic Development and Trade 1987). Most of these uses require high-grade silica (99 percent pure), which is supplied mainly by sources in Manitoba and the United States. However, rising freight costs may allow producers to upgrade the silica dioxide concentration of local sand. Alberta sources could eventually be used by local industry.

About 200,000 tonnes of gypsum are used annually at plants in Edmonton and Calgary to make wallboard. Although this amount is a large fraction of the gypsum used in western Canada, Alberta has no gypsum mines, but relies on sources in British Columbia.

Several gypsum deposits exist in the province, but they remain undeveloped due to remote or restricted locations or are difficult to extract. The best gypsum deposit is near Peace Point in Wood Buffalo National Park, but disposition or occupation of the land would contravene the National Parks Act. Another gypsum deposit near Fort McMurray contains about 2 billion tonnes of ore grading at over 90 percent gypsum. Extraction would require underground mining and likely will have to wait for the expected industrialization of the region and further development of the oil sands (Hamilton and Hora 1987).

It is feasible to mine more salt and peat moss, which, according to Hamilton (1984), are the most

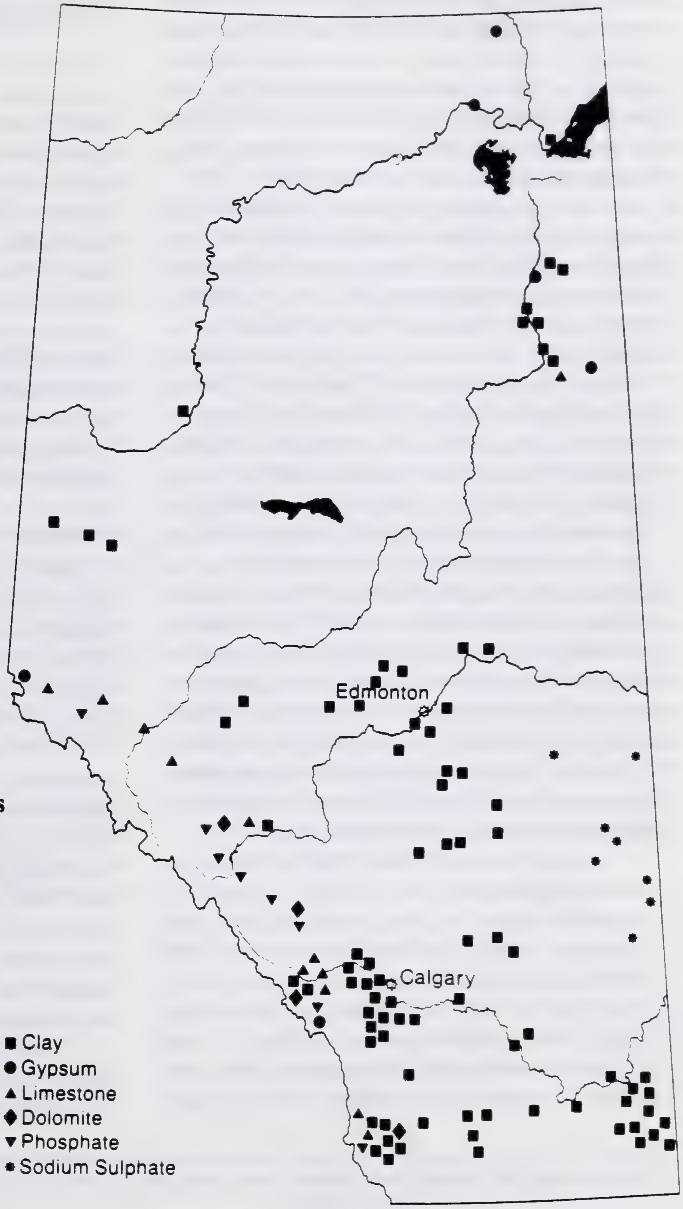

Figure 3. Industrial Mineral Deposits in Alberta

Note: Aggregate sources not shown.

Source: Alberta Chamber of Resources, Alberta Energy, and Alberta Geological Survey. 1987. *Alberta: Opportunities for Metallic Minerals.*

underdeveloped of the province's resources in relation to the size and distribution of their reserves.

Alberta's salt deposits are vast, underlying half of the province with salt beds sufficient to support a major brining operation* anywhere in the salt area. The wood pulp industry in Alberta and western Canada is a major market for the province's output of salt. The salt is not used directly, but in the form of chlor-alkali chemicals, including chlorine, sodium hydroxide, and sodium chlorate. Part of Alberta's salt production is used directly, for purposes ranging from household consumption to road salt.

Currently, there are two salt plants operating in Alberta: one at Fort Saskatchewan, where salt is extracted from beds 1,900 meters deep to make chlor-alkali chemicals, and one at Lindberg, where salt for domestic and industrial use is taken from beds 1,100 meters deep (Alberta Economic Development and Trade 1987). The use of salt likely will increase, mainly in conjunction with expanding chemical and petrochemical industries. The salt beds also are used for underground storage of petroleum products. Considerable potential exists to expand this use.

Peatlands cover 10 million hectares in the northern two thirds of Alberta. This extensive resource is virtually untapped. Some peat is processed and bagged for local or export markets and some is supplied in unprocessed, bulk form for local horticultural use. Production in 1987 was 74,000 tonnes valued at $14.4 million (Table 1). The development of these extensive reserves could affect other land and resource uses such as forestry and water management.

Alberta produces about 60,000 tonnes of sodium sulphate each year — about 10 percent of Canada's output — from a single plant 200 kilometers east of Red Deer near Metisko Lake (Alberta Economic Development and Trade 1987). Production in 1987 was valued at $2.8 million (EMR 1988). Alberta's sodium sulphate is very pure and is used mainly in detergents. Other uses are in the manufacture of glass, sodium chemicals, pharmaceuticals, and fertilizers, and in dyeing, tanning, and uranium processing. Reserves in the Metisko Lake deposit are estimated at 3 million tonnes. Several other deposits in Alberta are too small for development under present economic conditions.

Structural Materials

Of the structural materials produced in Alberta, the bulk consists of cement and lime, and sand and gravel or aggregates. Some stone is also produced in specific shapes and sizes for building and ornamental purposes. The most common types of this "dimension stone" are granite, sandstone, limestone, and marble. In 1987, production of dimension stone was 206,000 tonnes valued at $1.5 million (EMR 1988). This was mainly a very fine grained sandstone from quarries near Canmore. Small quantities of granite are also quarried near Fort Chipewyan. The dimension stone industry remains important because of interest in preserving and restoring historically valuable buildings.

Cement and Lime

In 1987, approximately 1,075,000 tonnes of cement, valued at $132,060,000, were manufactured in Alberta from limestone quarried at four mountain locations. In addition, about 260,000 tonnes of lime, valued at almost $18 million, were produced from limestone (EMR 1988).

The two largest quarries in Alberta extract limestone for cement making. At Cadomin, in the foothills south of Hinton, limestone is quarried for Genstar Cement in Edmonton. At Exshaw, near Canmore, Canada Cement Lafarge Limited quarries limestone for use in its plant on the site. Limestone is quarried at two smaller sites, one at Kananaskis and one in the Crowsnest Pass, to supply lime plants and to supply raw rock for various other uses.

Huge reserves of high-calcium limestone exist in rock formations exposed along many of the ranges of the Rocky Mountains. These limestone formations underlie the plains as well, but are generally too deep for exploitation, except in the northeast corner of Alberta. Shallow, flat beds of limestone are exposed in the Fort McMurray area (Alberta Economic Development and Trade 1987). Further development is feasible; however, expansion of the limestone and dependent industries will depend on greater demand from the construction and manufacturing sectors.

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* Salt is mined by injecting water into salt beds, extracting the brine, and then evaporating the water. The process is known as "brining" or "solution mining."

Aggregates

"Aggregate" is the term used for inert, hard construction materials, such as sand, gravel, crushed rock, or slag. In Alberta, only sand and gravel are of widespread commercial importance.

The availability, accessibility, quality, quantity, and cost of aggregate are important to Alberta's economy, because aggregates are used in most engineered works.

Sand and gravel are used in road construction, for the road base, to gravel county roads, and in asphalt and concrete. For example, these uses consume about 52 percent of aggregate extracted in the Edmonton-Lloydminster region (Edwards et al. 1985). Building construction is another major consumer of aggregate, for use in concrete, as fill, and in roofing materials. Construction works, including large projects such as dams, plant sites, and airports, use aggregate as a structural base, for drainage layers, as backfill, and in concrete. In Alberta, enormous quantities of aggregate are used at oil sands plants and in heavy oil recovery projects to provide a well-drained, sturdy foundation.

The manufacture of concrete products is another major consumer of aggregate, especially in the vicinity of Edmonton and Calgary. For example, Edwards et al. (1985) estimate that concrete products used almost 20 percent of the annual aggregate production in the Edmonton-Lloydminster region in 1981. Concrete products include sewer pipes, sidewalk blocks, steps, ornamental planters, and interlocking blocks.

Sand has industrial applications, including use in making glass products, as molds for refractory work, as an abrasive or filtering agent, and in the hydraulic fracturing of oil and gas formations.

The extraction of sand and gravel is a major industry. In 1987, Alberta produced more than 44 million tonnes of sand and gravel worth more than $141 million (Table 1). According to 1983 information (Edwards 1984), aggregate production in Alberta totals almost one half of the production in Ontario, but is more than that in any other province. In 1983, production amounted to almost 20 tonnes of sand and gravel for every Albertan, a rate of use about 40 percent higher than Ontario's. This statistic can be accounted for, at least in part, by the greater number of miles of road per person in Alberta, but it also reflects the amount, size, and nature of construction activity in Alberta. This aggregate was trucked by 7,000 to 14,000 independent truckers.

Most aggregate used in Alberta is sand or gravel; however, some uses require specialized products. Railway ballast, aggregate used as a base for railway tracks, is one of the few uses of crushed rock. Most of the rock used in Alberta is brought from British Columbia, although two limestone quarries near Nordegg also serve as sources of railway ballast. Burned clay (40,000 cubic meters in 1983) and recycled aggregate (over 114,000 tonnes in 1983) are also produced in Alberta (Edwards 1984).

Part Three

Demand Projections

Metallic and Non-metallic Minerals

The demand for most metallic and non-metallic minerals is determined primarily by changes in international supply and demand. Most minerals have a high enough economic value that transportation over long distances is economically feasible. The mineral market is thus a global one. If the demand for Alberta's mineral resources is to increase, then Alberta must supply its minerals to world markets at a competitive price.

The past 15 years have been turbulent for the Canadian minerals industry. Cyclical factors, including the energy crisis of the 1970s and the international recession of 1981-83, dominated supply-demand relationships. The failure of world mineral markets to recover fully from the 1981-83 recession marked a turning point for the Canadian minerals industry. Industry profits have remained low and revenues in real terms are lower than those for much of the 1970s.

Underlying these cyclical fluctuations have been important structural changes in mineral markets. World economic growth slowed, the metal content of finished products changed, and a different mix of goods and services was demanded by industrialized countries, which reduced the demand for many metals. In addition, minerals now face greater competition from a range of raw material substitutes such as ceramics, plastics, and composites. Finally, a rapid increase in the level and diversification of world mineral production over the past decade has contributed to excess capacity (EMR 1987).

Minerals now face greater competition from a range of raw material substitutes such as ceramics, plastics, and composites.

The latter half of 1987, however, saw substantial recovery in prices of most major minerals, an indicator that the long downturn in demand may have ended. The mineral industry is particularly subject to alternate periods of despondency and euphoria, in part because of the lumpy nature of increases in both capital needs and output on the supply side. Mines have to be large to be economically attractive and the development of a few new mines anywhere on the globe can substantially oversupply the market. A surplus in production capacity depresses prices for long periods until demand catches up, then prices tend to overshoot, reflecting the shortage of supply and the higher price required to build additional capacity. This in turn results in an oversupply, and so on. Competition and substitution are, of course, important factors, but a major problem in minerals development is internal to the industry — the difficulty of matching supply and demand.

Structural Materials

The demand for structural materials reflects the level of construction activity in a local area. As noted earlier, the value of structural materials is shared almost equally between cement, and sand and gravel. Although Alberta's rich resources of sand and gravel are found in a variety of geologic formations distributed throughout the province, they are not available everywhere in accordance with local need. Local shortages are occurring and haulage distance will be an increasingly critical factor in future developments (Alberta Economic Trade and Development 1987).

A detailed study by Edwards et al. (1985) provides a clear picture of the situation in the Edmonton-Lloydminster region. The generalized conclusions probably apply throughout the province.

The Edmonton-Lloydminster region produces about 40 percent of the province's aggregate. Commercial operators produce 75 percent of this, mostly for use in road construction (52 percent), concrete production (18 percent), or asphalt production (11 percent). Edwards et al. (1985) predicted that demand for aggregate in the region would rise from 10.8 million cubic meters per year in 1983 to almost 14.5 million cubic meters per year by 2010. A review of these projections and comparison with 1985 Statistics Canada data has shown the projection to be accurate to this point (Edwards, pers. comm., May 1988).

Although geological data indicate 1.1 billion cubic meters of gravel and 3.9 billion cubic meters of sand in the region, consumption estimates predict over 300 million tonnes of gravel, or 25 percent of the resource, will have been consumed by 2010 (Edwards et al. 1985). This 25 percent depletion estimate does not take into account loss during extraction, or the permanent loss of deposits to other land uses. Extraction losses commonly range from 5 to 15 percent, varying from pit to pit and by area (Hudson, pers. comm., September 1988). Losses to other uses will depend on the growth and location of other activities, primarily urban expansion. Edwards (pers. comm. May 1988) indicates that loss of access has "sterilized" as much as 90 percent of all deposits in heavily populated areas such as southern Ontario.

Within the Edmonton-Lloydminster region, the sand and gravel deposits are distributed unevenly, and demand varies from locale to locale. For example, in the Cold Lake area, coarse gravel aggregate is not plentiful. New projects, related to the in-situ development of oil sands and heavy oil deposits in that area, will require substantial amounts of aggregate for well pads, roads, and building sites. The existing supplies could be rapidly depleted. In the area that supplies Edmonton, over half of the most useful gravel supplies may have been consumed by 2010. Should any of the major deposits near Edmonton be directed into land uses that exclude aggregate development, Edmonton and the adjoining municipalities will encounter escalating aggregate costs.

One area with considerable growth potential is the use of lime in agriculture. More than 2 million hectares of acid soils in Alberta and the Peace River region of British Columbia could benefit from applications of lime, as has been demonstrated in many experiments. Based on the amount of acid soil expected in 1985, and an application rate of 4.5 tonnes per hectare (to raise the soil pH by 0.5), about 320,000 tonnes of lime was estimated to be needed annually in order to prevent soil acidification. An additional 390,000 tonnes per year would be required to raise the pH of soils with a pH of less than 5.5 by 0.5 in 10 years' time (Hoyt n.d.).

Farmers have barely started to use lime. This is due to many reasons, including the cost of transporting a bulky material long distances. Alberta has encouraged the application of lime through the Agricultural Lime Freight Assistance program. In 1985, the program provided grants of over $340,000 to 87 applicants for 12,000 tonnes of lime or marl. As of April 1, 1988, the program paid 9 cents per tonne per kilometer for hauls of up to 200 kilometers, 7 cents for hauls of 200 to 400 kilometers, and 6 cents for hauls of 400 to 600 kilometers. The maximum grant per application is $8,000.

Part Four

Managing Resources For The Future

The development of Alberta's mineral resources already makes an important contribution to Alberta's economy. Considerable expansion is possible, but it will be difficult to develop a policy for managing resources that will contribute to a long-term sustainable economy. The problem is that we lack detailed information about the location and extent of our mineral resources.

The exploration being encouraged by the provincial government is an important first step toward an overall management strategy. Good management depends on a good data base. Once potentially useful mineral deposits have been identified, steps may be taken to ensure that access to the deposits is maintained and that the option to exploit these resources is not squandered by lack of foresight.

The situation with structural minerals, especially sand and gravel resources, is especially difficult. The demand for these resources comes from the immediate area and an inventory is important in planning major construction projects. Because both supply and demand are local, responsibility for management generally has been placed with local government. Although several provincial Acts affect land use and aggregate extraction and processing, there is no provincial policy for aggregate development. Nor is there a provincial government department, with a comprehensive mandate over the resource, that can advocate policy.

Regional plans guide development in the areas they cover. The availability of aggregate is affected by land use planning, since lands may be zoned or otherwise designated to protect or preclude aggregate extraction. Thus, the potential for development of sand and gravel deposits depends not only on the physical characteristics of the deposit and the economic conditions, but also on local zoning.

Municipal plans are more detailed than regional plans and often lead to land use bylaws directed specifically at aggregate deposits and operations. It is extremely important for municipal planners and administrators to be aware of the aggregate resources within their jurisdiction and the role those resources play in the regional context.

The Alberta Research Council undertook a major inventory program, with funding split between the Research Council and the Department of Forestry, Lands and Wildlife. However, this program has been cut back and, in many areas, adequate aggregate information is not available. The result is that many planning decisions will be made without enough data to accurately assess the present and future impacts on the resource.

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The importance of inventory data in land use planning is illustrated by the following information about Alberta's sand and gravel resources. It is estimated that Alberta has aggregate reserves of 8.72 billion cubic meters of gravel and 8.77 billion cubic meters of sand. These sand and gravel reserves cover about 1,407,000 hectares (Edwards 1984). At a regional level, 585 deposits of sand or gravel were identified in the Edmonton-Lloydminster area (Edwards et al.). These data would seem to indicate an abundance of sand and gravel, but only 226 deposits are possible sources of gravel and, of these, only 74 have over 1 million cubic meters of gravel — a few deposits contain most of the resource. The situation is similar in other areas of the province. In some counties, the reserve is concentrated in one site. The protection of these critical reserves is very important. A significant portion of an area's aggregate resources could be lost if a single major deposit became "sterilized," that is, made inaccessible through assignment to an incompatible land use. While there is no immediate shortage of sand and gravel province-wide, severe shortages are occurring in some counties. As a result, costs are rapidly escalating for structural materials and the construction of engineered works.

Another important consideration in planning the long-term management of aggregates is the quality of the resource. Inventory data may give a false impression of the accessibility of the resource and the security of supply. The better aggregate reserves and those close to the areas of demand are being depleted preferentially. As a result, the resource is diminishing in both quality and quantity. The status of reserves changes rapidly with heavy use, and without frequent updates of regional or local inventories, even where inventory data exists, municipalities may be making plans based on outdated information (more than five years old). Without a continuing inventory program, municipalities may be forced to conduct their own inventories of local sand and gravel reserves to assist with local land use planning.

Regional and municipal plans prepared before detailed aggregate information became available should be re-examined and revised as necessary to incorporate aggregate data. According to Edwards et al. (1985), it is essential that each jurisdiction consider its total reserve, availability of the resource, location of deposits, and current and future requirements for aggregate.

As good-quality aggregate becomes scarcer and more expensive, it is possible to increase the amount of synthetic aggregate produced in Alberta. Common clay, available in most geographic regions, is an attractive source of materials for making synthetic aggregate. Manufacturing plants could be built very close to the market in areas deficient in sand and gravel.

Synthetic aggregates are considerably lighter than natural aggregates, thus reducing fuel costs for transportation and the amount of reinforcing steel required in structures. Disadvantages include the high cost of heating fuels, the lower crushing strength, and the presence of contaminants. At present, about 90 percent of the synthetic aggregate produced is used in concrete masonry blocks, 5 percent in structural concrete, and 5 percent in specialty uses such as horticulture. In 1983, a cubic meter of manufactured aggregate cost between $36 and $40. About 30 percent of this price was related to energy costs.

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In 1983, Consolidated Concrete manufactured about 40,000 cubic meters of synthetic aggregate. The probable provincial capacity to produce synthetic aggregate is only about 200,000 cubic meters per year (Edwards 1984). Even if the production of synthetic aggregates increased to the full potential, the overall contribution to the aggregate supply would be a small fraction of the total annual demand.

Crushed rock is a primary source of aggregate in many parts of North America but is not widely used in Alberta because of the abundance of sand and gravel deposits. There is almost unlimited potential to produce crushed rock from suitable materials found in the mountains; however, using crushed rock would mean major transportation costs and potential environmental concerns. The mountains have other important land uses including parks, recreational areas, and wildlife habitats. Crushed rock from the mountain areas will not become competitive with sand and gravel until the current sources of sand and gravel are nearly depleted.

Other materials could be used as substitutes or supplements for natural aggregates. These include ash, sulphur, and recycled concrete, asphalt, or crushed glass. The major use for fly ash is as an aggregate alternative in construction fill. Large amounts of this material are available from coal-fired electrical generating plants. Recycled concrete and asphalt from demolitions and road improvements is a viable source of aggregate in an urban situation. Edmonton has established three collection and crushing sites. The program has resulted in more material being recycled each year, reaching 114,000 tonnes in 1983. The City sees several benefits in the program, including preservation of mineral aggregates, a saving on hauling to disposal sites, and conservation of landfill space. Glass can also replace aggregate, but it has higher value in the production of new glass. Recycled glass is readily available through the beverage container collection system; however, given the current demand for recycled glass to make new containers, it is unlikely that recycled glass will replace aggregate in substantial amounts. The situation could change drastically if the glass plant in Medicine Hat, the main purchaser of glass scrap in western Canada, were to close. Under those circumstances, the use of glass as an aggregate might become an economically and environmentally attractive alternative for disposing of non-refillable glass beverage containers.

Similarly, sulphur could be used as an extender in asphaltic concrete, but it has a higher value as a component in fertilizers and industrial processes. World demand for sulphur should continue to be strong for the foreseeable future.

Aggregates are essential to construct and maintain Alberta's infrastructure, and a continuing and, most likely, increasing supply of these materials is necessary. There is no physical lack of aggregate reserves or substitutes for sand and gravel in Alberta. The critical question is one of cost. What are Albertans willing to pay for aggregate? At what point do costs begin to deter development in Alberta? Steps should be taken to manage these resources for the long-term benefit of Albertans.

Part Five

Interactions With Competing Uses

What are the impacts of mineral developments? The extraction of minerals, including sand and gravel, affects other resources and resource users. The major effects will be those typical of any surface disturbance, but since mineral resource extraction activities (except for the large number of sand and gravel pits) currently are few and local, the direct impacts likewise are localized and usually minor. Mineral development has a considerable influence on the land surrounding the operation. This influence is referred to as the "shadow effect." Figure 4 illustrates the possible wide-reaching conflicts that mining can have with other resource uses and the constraints that these uses may place on mining developments. As Marshall points out,

> *The range of interaction between mining and other land uses has become increasingly complex. . . . Demands for resource conservation, environmental protection, and restricted use, coupled with the wide range of traditional uses — agriculture, forestry, settlement, recreation — have all increased the potential constraints on development and the actual number of conflicts* (Marshall 1982:193).

Urban sprawl, park development, the presence of heritage resources, water quality or fisheries concerns, and so on, all may restrict the development of mineral resources such as sand and gravel. If resource extraction proceeds, there may be conflicts with these other resource uses. But as Simpson-Lewis et al. note,

> *The past conflicts between pits and quarries and other land uses are giving way to constructive compromise and landscape re-creation* (Simpson-Lewis et al. 1983:193).

If major mineral deposits were found in Alberta and these resources and the necessary supportive infrastructure were developed, then problems with other resource users could become more serious. For example, although the impacts of present placer mining operations are insignificant, interest in placer mining leases continues to be high. If large gold finds were made and placer mining became a major extraction industry, this could have a large and detrimental impact on aquatic resources and water quality.

In other cases, impacts are, and are likely to remain, local in importance. For example, land disturbed in Alberta by aggregate development totals about 10,500 hectares — a relatively minor amount, but almost as much as the total area disturbed by oil sands mining (4,850 ha) and coal mining (8,280 ha) combined (Bird and Rapport 1986). The industry, however, is prone to generating concerns because, to be economically efficient, aggregate must be extracted as close as possible to the urban areas where it is needed. The proximity to populated areas heightens public awareness of the industrial operations, and increases the chance of land use conflicts. Concerns may also arise in agricultural areas, but there the development of sand and gravel pits and the associated hauling business may generate local job opportunities and off-farm income to the advantage of the local community. The sale or leasing arrangement made between the land owner and the developer directly benefits the landowner. These direct benefits of resource extraction are not as obvious to the general public in urban areas.

In general, the problems between mineral development and other land uses and resource users can be broken down into impacts on other land uses, concerns arising from the day-to-day operations, and impacts related to site abandonment and reclamation. Conversely, mineral resource development can be constrained by other activities or developments occurring in an area of mineral reserves.

Laws and regulations exist to address the impacts of industrial operations, including those of mineral extraction, but these may not consider or satisfy all of the concerns of other resource users. At the heart of many concerns about

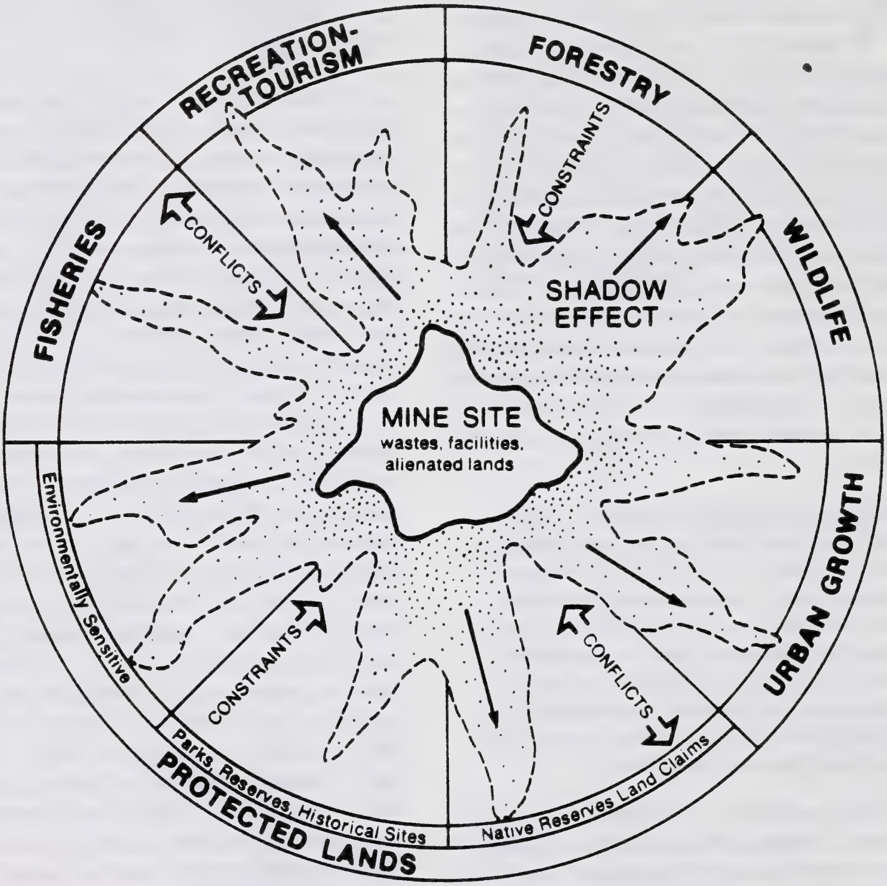

Figure 4. Land Use Conflicts and Constraints for Mining

Source: Marshall, I. B. 1982. *Mining, Land Use, and the Environment 1: A Canadian Overview*. Environment Canada.

mineral development, as well as other types of industrial development, are the questions: what type of future do Albertans want and what level of development is needed or desirable to support that future? The following discussion is intended only to highlight some of the issues related to mineral development. It is hoped that the development of an Alberta Conservation Strategy will lead to processes that will address the broad issues of dealing with conflict among resource users.

Restrictions on Land Use

A major consideration in the development of mineral resources is the restriction of land use. The extraction of minerals is incompatible with other land uses during the active mining phase, and because the land surface is disturbed, forestry, agriculture, recreation, and similar activities cannot take place at the same time as mineral extraction over the active part of the lease. Some activities are compatible; for instance, clay or sand and gravel may be mined jointly with coal.

Other land uses may also be affected by mineral extraction. For example, habitats will be altered, permanently or temporarily. Once reclamation is complete, habitat may be restored. In very specific instances where mineral resources occur under unique habitats, extraction may destroy areas critical to a plant or animal species. In other instances, sand or gravel development may create habitat that extends the range of species. This was the case in an area in southern Alberta. The northernmost occurrence of the long-toed salamander, and its only known occurrence in Alberta, was in a gravel pit. Plans to expand the gravel extraction operation, which might have destroyed the habitat, were put on hold after the discovery of the salamander.

Mineral extraction usually is incompatible with parks and outdoor recreation interests and preservation values, such as in areas where unique habitat, such as sand dunes, is to be preserved. The need for the mineral resource must be weighed against the future recreational use of the area. In some instances, total prohibition of mineral extraction may be the appropriate policy. Thus, mineral extraction is not allowed in national parks. In other areas, it may be appropriate to extract the mineral resource and then reclaim the area to the desired recreational use.

This alternative may be appropriate for mineral resources with high intrinsic value because of their proximity to markets. Thus, the sand and gravel deposits in urban areas could be extracted before area is needed for other uses or before it is consumed by urban sprawl. An alternative is to set aside important sand and gravel deposits for recreation areas or other uses that do not make the resources permanently inaccessible, on the understanding that at some time the area will be exploited for the underground resource.

The difficulty with this latter alternative is dealing with the expectation created in the public's mind when the recreational reserve is established. These problems are clearly evident in a situation in British Columbia. In this instance, a company wanted access to an area leased for mineral rights many years ago, but never developed. A provincial park was changed in status to a recreation area in order to allow mineral extraction that otherwise would have been prohibited. The public opposed this move with blockades resulting in arrests, but a court injunction eventually gave the company access to the mineral resource. The earlier in the planning process that potential mineral resource development can be identified, the better. Mineral deposits are better left outside park boundaries than inside. If the mineral resources are included, the location of the deposit and the location and routing of associated facilities (roads, mine head, tailings ponds, and so on) should be identified as early as possible so the potential damage to the parks' attributes is fully appreciated.

When the extent, quality, and quantity of mineral resources are unknown or there is little current interest in the exploitation of known reserves, planners and resource managers are faced with the particularly difficult task of making land use decisions based on uncertainties. While it is desirable to keep options open, decisions must be made, and in the face of demands from a variety of interests, mineral resources may not be adequately protected unless better information is available to support the interests of this sector.

Operational Impacts

Most plant operations and haulage of sand and gravel depend on local labor and local companies. This increases cash flow into the local economy to the benefit of the community. However, these same operations may cause public concern about the impact of increased traffic on the quality and safety of local roads.

Sand and gravel operations in stream valleys may hamper the movement of wildlife using the valleys as migration corridors. If aggregate is extracted from the stream bed, aquatic habitat may be destroyed and downstream areas silted.

In other areas, the sand and gravel deposits usually are groundwater recharge areas and extraction of the resource may disrupt groundwater flows and affect local wells. Sand and gravel is often washed to remove undesirable materials and improve the consistency of sorting and grading. These washing operations must meet guidelines laid down by Alberta Environment (1980) to minimize siltation or contamination of water courses.

Extraction, cleaning, and sorting of aggregate may also create dust and airborne particulates. The impacts are mainly aesthetic and of greatest concern when close to human settlement or scenic areas. Despite this concern, mineral resource extraction activity in the Canmore corridor seems to have little effect on recreation and tourism in the area. This is the result of the successful use of inventory data and reserve information by the Calgary Regional Planning Commission and in area planning processes to ensure that recreational developments in the corridor and in Kananaskis Country did not conflict with the necessary development of aggregate reserves.

The impacts of metallic and non-metallic mineral developments may be more severe than those of siltation or dust associated with sand and gravel development and could include toxic and chronic effects of pollution. These are not presently a problem in Alberta because of the small amount of mineral development. Likewise, no problems have resulted from the small-scale extraction of peat for horticultural purposes.

Reclamation Opportunities

After a resource has been extracted, areas must be reclaimed in accordance with guidelines produced by Alberta Environment. The main problem with the reclamation of aggregate pits and quarries in Alberta is inspection and enforcement. Many private landowners feel that they can do as they like on their land. Many small operations are established without going through the application and permit approval process (Edwards 1984).

Many sand and gravel pits, especially borrow pits for road construction, are quite small. Guidelines require topsoil to be salvaged and stockpiled and returned to the site when the pit is closed. The reclamation of these sites offers good potential to restore and enhance either terrestrial or aquatic wildlife habitat.

Even in the mountains and foothills, where forestry is recognized as the primary land use for reclaimed areas, wildlife habitat might be incorporated as a secondary land use.

The critical decision in reclamation is to establish the appropriate end use of the reclaimed land. It is not sufficient to assume that the previous use is the most appropriate.

For example, the previous use may have been rough grazing on Canada Land Inventory Class 5 land in a semi-arid region. An alternative end use might be as a pond, capable of supporting a sports fishery and water recreation. The final use should be determined by assessing costs, the availability of other recreational facilities, the impact on groundwater of the new pond, the implications of increased traffic on local roads, the impact on the agriculture community, and many other matters.

Normally the end use of the reclaimed land is proposed by the applicant in the development proposal. The end use must comply with any area Integrated Resource Plan, the Planning Act, and with the broad "zoning" that exists in Regional Plans.

Applicants usually consult with the local zoning authority to arrive at an end use that is compatible with the goal of "equal productivity," that is, productivity on the reclaimed land equal to that which existed previously. The application is then reviewed by the provincial government's Development and Reclamation Review Committee to ensure it complies with provincial legislation.

Resource Sterilization

Aggregate deposits may be permanently removed from potentially available supplies because of a commitment of the land that excludes aggregate extraction. This "resource sterilization" usually results from building on the deposit or from a potential conflict with the adjacent land users.

The most common location of resource sterilization is around large urban areas. For example, one river valley pit in Edmonton is no longer used because a subdivision has been built around the area. In Calgary, full use of the gravel deposits under Nose Hill conflicts with the development of a city park in the same area.

Improperly managed urban growth may destroy the best and least expensive sources of building materials. The cost of aggregate sterilization due to urban expansion or re-zoning of urban areas or urban fringe areas, as measured by the loss of aggregate reserves and the increased cost of alternative supplies, is in the billions of dollars (Edwards, pers. comm., May 1988). This is money that could be used for reclamation or research into alternate sources or more effective inventory programs. Urban planners should consider carefully the conservation of aggregate resources and plan development in a manner that utilizes them most efficiently. Land-use zoning may be needed to protect resources for future development.

Resources are also sterilized fairly frequently when pipelines or transmission lines cross the deposits. A considerable amount of the deposit must remain untouched because of the buffer zone around the line.

Land administrators should know where aggregate deposits are in their area and which land uses might permanently remove those resources from production. If mineral resources are not considered in the early stages of land use planning, it may be extremely difficult or impossible to gain access to them in the future.

Part Six

Legislative and Regulatory Regime

No licence or permit is required for prospecting, geological mapping, or surface or airborne geophysical and geochemical surveys. Where exploration may disturb the surface, exploration permits and approvals are required. The approvals needed depend on whether the minerals are Crown-owned or privately owned, and the type of mineral under consideration.

The Public Lands Act authorizes the Department of Forestry, Lands and Wildlife to make regulations governing the exploration for minerals on public land. It also empowers the department to take measures to prevent surface disturbances and to prevent unlawful removal of sand, gravel, clay, or marl. The regulations dealing with the development and operation of quarries, and the rate of removal of minerals owned by the Crown, are governed by the Mines and Minerals Act administered by the Department of Energy, Energy Resources Sector, Mineral Resources Division. The Mines and Minerals Act applies to minerals underlying privately owned land, except for sand, gravel, clay, and marl. The Law of Property Act grants ownership of those minerals to the owner of the surface of the land. The owner is entitled to full use of these minerals, including removal by excavation. The owner of the land surface may also disturb other regulated minerals in the course of farming or other operations that are permitted on the land surface.

Access to minerals other than sand, gravel, clay, or marl underlying privately owned lands is governed by the Surface Rights Act. The Surface Rights Act denies the right of entry to an operator unless the landowner's consent has been obtained or an order of the Surface Rights Board has been obtained. The Act also defines the entry fees payable by an operator to a landowner and outlines a process to determine compensation when there is no agreement between the two parties. Though the focus of the Surface Rights Act is on private land, it also applies to occupied Crown land.

There are pieces of legislation that govern minerals extraction regardless of ownership. The Quarries Regulation Act, for instance, deals with excavation for any mineral other than coal. Its focus is on the operation of quarries, especially safety. Also, sand and gravel washing must comply with the Fisheries Act of Canada and the Waste Water Management Guidelines for Alberta Sand and Gravel Washing Operations (Alberta Environment 1980). The latter are designed to keep pollution levels within the objectives of the Alberta Clean Water Act. These guidelines relate mostly to the direct discharge of suspended solids into a watershed. In addition to specifying the quality of discharged water, the guidelines specify measures to prevent erosion of the banks of the receiving body as water is discharged into it.

Mineral extraction also must comply with other Acts, such as the Agriculture Service Board Act, the Soil Conservation Act, the Heritage Sites Act (if an historical or archaeological resource might be affected), the Municipal Government Act, and the Planning Act. The Land Surface Conservation and Reclamation Act also applies to pit and quarry operations on Crown and private land. The Act is designed to ensure that affected lands are restored to a capability equal to or better than that prior to the beginning of operations. The Act does several things to achieve this objective. The Minister of Environment may require that an Environmental Impact Assessment be prepared. Under the Act, the Lieutenant Governor in Council may authorize the Minister of Energy to expropriate minerals on or under any land to prevent environmental degradation or inconsistent use of land due to exploration and recovery. Pits and quarries can be designated as regulated surface operations that require approvals to operate, and requirements for land conservation and reclamation can be specified at the time of approval. Security deposits from the operator are required to ensure satisfactory reclamation.

The Land Conservation and Reclamation Division of Alberta Environment administers the Act. The Act provides for a six-stage process for reviewing and approving applications for reclamation orders, and issuing of certificates of approval. These stages include: submission of a development and reclamation plan, approval of the plan, posting of a reclamation bond, issuance of reclamation orders if reclamation work is not approved, issuance of surface control orders if an operator fails to comply with a reclamation order, and issuance of reclamation certificates and subsequent return of the reclamation bond.

Guidelines for reclamation of land in Alberta were issued in 1977. These are currently being amended. The guidelines provide direction and establish minimum requirements for drainage and erosion control, conservation of reclamation materials, backfilling, recontouring, reconstruction of the root zone, restoration of services and utilities, and post-mining land management. The guidelines also include a revegetation plan that requires the developer to establish and maintain a self-sustaining plant community that will develop into a predetermined agricultural, forest, wildlife, or other use of at least equal productivity to that which existed prior to disturbance.

The Sand, Gravel, Clay and Marl Surface Operations Regulations, enacted in 1982 under the Land Surface Conservation and Reclamation Act, apply to pit operations on private land. Pit operators need a Development and Reclamation Approval, so that the pit is reclaimed and the land around it protected. This requirement applies to all "large pit" developments, basically those where the disturbance will exceed two hectares. Alberta Environment is inventorying operations and notifying operators of the need to comply with these regulations. By April 1, 1986, 1,440 pit operations had been recorded in 31 municipalities. Approval was required for 493 of these operations. The remainder were either inactive or very small (Alberta Environment 1986). Small pit operations do not need a Development and Reclamation Approval, although the landowner is responsible for reclamation when the pit is abandoned. Reclamation as the pit is being excavated is encouraged.

Part Seven

Conclusion

The minerals sector in Alberta is faced with both opportunities and problems. Opportunities exist to begin or expand production of several metallic and non-metallic minerals. This potential cannot be realized, however, as long as knowledge of the province's mineral resources is incomplete. Exploration is being encouraged and interest in Alberta's mineral resources has increased in recent years. More information about the mineral resources is important if conflict between extraction of these resources and other activities, such as recreational and tourism developments, agriculture, or forestry, is to be minimized. More could be done to encourage mineral exploration so that this knowledge base is available, but should this be the responsibility of government or of industry?

One possibility is to take more advantage of the extensive drilling that occurs in the search for oil and gas. Cores from near-surface depths are not normally examined in the search for oil and gas, but coordination of information available from sources such as drilling logs might efficiently improve our knowledge of Alberta's minerals. Analysis of formation waters and cores samples from the shallow depths of oil and gas wells are sources of information.

In comparison to the unknown and underdeveloped potential of metallic and non-metallic mineral resources, much more is known about Alberta's structural minerals resources, enough to recognize that shortages and increasing costs, particularly of sand and gravel, are problems for the immediate future, but not enough to know exactly what the options are and how problems might be minimized. More information is needed, but the development of sand and gravel resources is more a matter of local than provincial responsibility. It is not certain that the resource is adequately protected in the long term under this management regime, but is more involvement by the provincial government the answer? Would improved awareness of mineral resource management issues at the regional and local level suffice?

Past aggregate development practices have left Alberta with a legacy of unreclaimed sand and gravel pits. Alberta Environment is moving toward remedying the situation. This provides an opportunity for communities to help develop reclamation plans that combine economic efficiency with an end land use best suited to local plans. In recognition of the variety of interests and points of view on land use, restoration of disturbed lands to a capability "equal to or better than that prior to disturbance" may no longer be an appropriate goal.

Past practices of some land uses, primarily urban expansion and industrial development, have left some resources, particularly sand and gravel deposits, no longer accessible. Already there are areas in Alberta where sand and gravel resources of suitable cost and quality are difficult to find. The value of these irrecoverable resources may be billions. Costly mistakes can be avoided through careful planning, based on a sound resource inventory and coupled to local development plans. A sound resource inventory is needed, as is recognition by planners and developers at all levels that Alberta's mineral resources are valuable non-renewable resources

Costly mistakes can be avoided through careful planning, based on a sound resource inventory and coupled to local development plans.

that should be managed for the long-term benefit of Albertans. Effective management must both protect the resources to meet future needs and recognize the concerns and interests of other resource users in developing Alberta's mineral resources.

Two objectives from the Edmonton Regional Planning Commission's Sand, Gravel and Clay Policy (1978) sum up the conflicting interests of various resource users.

> *The Commission recognizes sand, gravel, and clay as necessary and valuable non-renewable resources and will aim to protect and maintain the resource until such time as it is deemed available or appropriate for use, for the continuing benefit of the Region and adjoining jurisdictions. The Commission will conserve not only the resource but also areas desirable for the establishment of associated industry.*
>
> *The Commission will aim to ensure that extraction takes place in a manner that minimizes conflicts, maintains a satisfactory quality of natural and community environment during operational life span, prevents permanent damage to the landscape, and achieves the highest reclamation potential of the disturbed lands.*

If similar objectives were to be incorporated into all plans, the development potential of Alberta's minerals would be assured in a manner in keeping with the philosophy of an Alberta Conservation Strategy.

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